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Site Evaluation by Means of Hydrological Data Assessment

Developments in Dynamic Soil Moisture Determination

The spatial distribution of various soil types causes uneven water content in the upper soil. The same is true with the same amounts of precipitation. Currently hydrological site evaluations are usually made with common geo-physical methods, which make it possible to predict depletion and saturation conditions based on analysis results. With the development of a dynamic TDR field moisture gauge, soil moisture in a thin soil layer (h = 3 cm) can be ascertained.

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He works in a collaborative project with Dr. Rolf Becker, IMKO Micromodultechnik. The objective of the governmentally funded project is the development of real time equipment, to highlight soil moisture on the go.

Keywords

Dynamic hydrological evaluation, soil moisture, Time Domain Reflectometry TDR, TRIME

Literature

Literature references can be called up under LT 06306 via internet http://www.landwirtschaftsverlag.com/landtech/local/literatur.htm.

The data, gained with advanced precision farming, forms an infinite range, which provides an empirical basis to improve agricultural production. Field specific properties of hydrology have to be derived from geophysical analysis.

The innovation of a recently developed dynamic measurement system enables a fast empirical site evaluation, due to discovered field moisture. The advanced technique has been derived from Time Domain Reflectometry (TDR). It is to transfer the observed value into the information pool of site specific farming and consequently to overcome the aforesaid information gap.

In order to use the acquired data for analytical purposes it is obligatory to allocate the data spatially. Considering additional data, as electrical conductivity, climatic data and appearing draft force documentation, these values are to be consolidated further.

Methods

TDR readings are facing a certain interference of objects, not defined by the determination of soil's general bulk density. So an anomalous proportion within the probe´s measuring volume leads to a misinterpretation of the gained data. Air filled pores and water filled gaps above average proportion as other non represented materials are severely interfering correct readings [5, 7]. Fork shaped conventional probes are particularly sensitive to appearing stones. The disadvantageous effects on TDR readings have been exemplarily investigated for the task of stationary measurements (fork shaped probes, TDR and TRIME) in standard soils of southern Germany. The abstract kind of influence, the failure potential, on dynamic measurements stays the same (deviation of waves, the potential appearance of full reflection, appearance of underestimated pores etc.). Due to the probes propagation speed and the consequent flux of soil around the probe a higher failure potential is likely. By modifications of the progression angle, probe geometry and a further development of the used electronics (IMKO) the mean deviation of the acquired data could be significantly lowered (*Fig. 1*). The modified TRIME device (Time Domain Reflectometry with Intelligent Micro Elements) generates a pulse of 200 mV in a time of 20 ps (1 ps = 10^{-12} s). The voltage surge causes the propagation of an electromagnetic pulse, whose reflection is determined in time. The volumetric water could be assigned equivalently. Facing the momentary probe design, the resolution gives a shallow horizontal moisture image (@ -3 cm). The waveguide is set under the ceramic plate, which has exceptional anti abrasive characteristics. The appearing energy

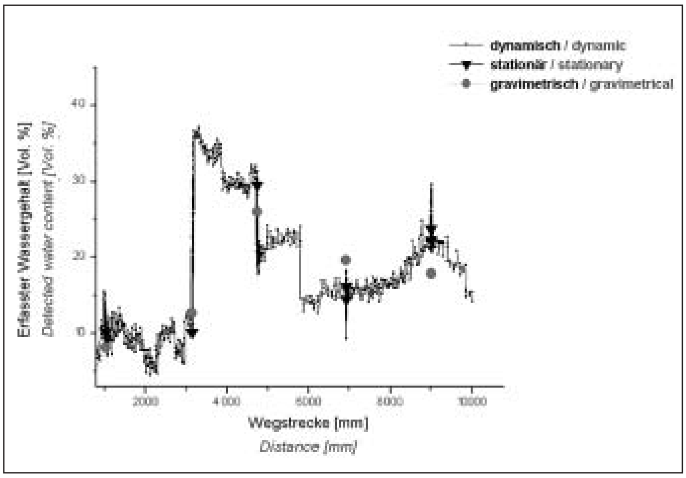

Fig. 1: Online detection of water content vs. TRIME P2G and gravimetrical evidence (DIN 18121)

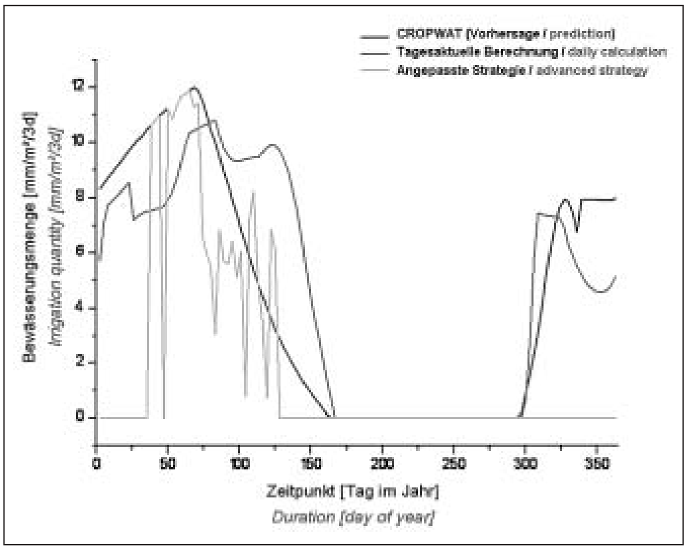

Fig. 3: Comparing different irrigation strategies due to variation of decisive data

of the electric field was simulated and further analysed. With an appropriate 95% fraction of energy, the major part of the measuring field is characterized visually (*Fig. 2*).

An additional detection of electrical conductivity (EM 38) is provided to the dataset. The EM 38 originates from geo engineering and gives an actual value of apparent electrical conductivity (dS/m) on a varying penetration depth of about 1 to 1.5 m. Through this conditions of drainage or saturation can be identified. With an increasing number of moisture acquisitions in different layers, over a period of varying precipitation or differing irrigation amounts, a prediction of field water status is possible using a moisture balance calculation. The basis is generally provided by actual weather data and the current topsoil water content. Areas of varying drainage capacity and areas of high water holding potentiality (reverse) can be outlined.

Results

The moisture acquisition of a shallow soil layer facilitates a simple mathematical model. This allows simple assumptions of prevailing conditions in the observed top soil layer. This is prepared by using dynamic TDR (dTDR) data and $\sum$ moisture (0 to -1 m) values to be automatically transferred to a database. Technically, this is realized, using the analogue output of dTDR in combination to the serial interface output of the EM 38, which both is referenced to spatial allocation (GPS/Glonass System). The interface of dTDR provides a signal of 0-1V. Further amplified by 10, it is transmitted to a DAQCard interface (6024E) of a portable computer. The data is collected by DASY-Lab. In addition to the moisture, acquired dynamic in a volumetrically scale, the formed data set contains: period, position, physical penetration depth (probe), tri axial force documentation. Laboratory trials and soil bin test series showed a high regression coefficient of stationary TDR-readings to dTDR. The gravimetrical validation was discovered significantly high (*Fig. 1*). This forms the initial of an instant evaluation of varying hydrological capacities.

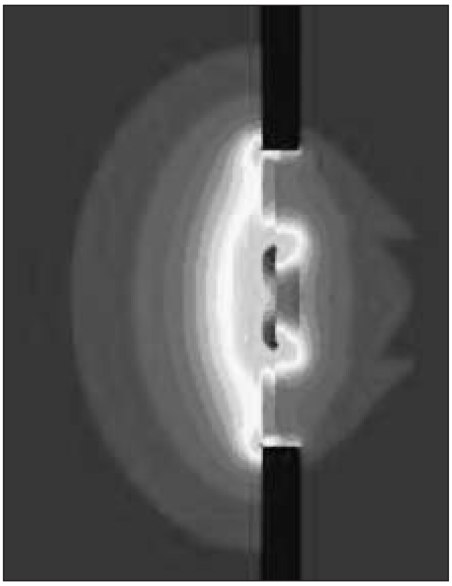

Fig. 2: Field distribution of the dynamic sensor (outside, left: inside, right)

A foregoing stationary validation of this approach showed excellent results. The prediction of actual depletion could be proofed for relevant depth (root zone) in an irrigated fruit orchard. The trial was conducted for litchi trees on a slope of a subtropic climate location. Prediction models of plant water requirement as the basic Penman-Monteith approach [8, 10] and CROPWAT [1, 2, 11] were rated. For the first step of validation, various spots were equipped with TDR and Tensiometer moisture detection probes (depths of -12, -25, -45, -70 and -100 cm). Therefore a basic hypothesis of actual irrigation requirements was possible. Using additional field specific climatic information, a modelling on field scale was qualified. A subsequent validation process was leading to a further adjustment of suggested plant water requirements. Basics were derived from crop coefficients for litchi [9]. Via xylem-flow documentation [4] and the determination of apparent photosynthesis rate, the gained data was trimmed, modifying the coefficient. First assumptions from soil moisture balance calculation were further refined [6, 11, 12]. *Figure 3* shows a comparison of CROPWAT computed irrigation scenario in comparison to currently calculated irrigation requirements and an advanced irrigation strategy, which was derived from the data fusion of predicted depletion and maximum xylem flow at prevailing climatic conditions.

The dynamic moisture acquisition approach showed coherent data for a shallow layer. The apparent properties of layers underneath are recorded by a dynamic non-contact measurement of electrical conductivity, which is producing a value of electrical conductivity. The EM 38 measurement contains a selection of affecting measurands (water content, salinity, pore size, texture) [3, 13]. DTDR provides a reference for the simultaneous acquisition of electronic conductivity. Solitary water content acquisition by EM 38 is found impossible. However, in contrast the fusion of the two datasets allows a clear validation of field water depletion and saturation status. These findings have to be verified in a further trial setup, sizing impact families down to the very basic limiting factors.

Conclusion

Stationary trials resulted in significant correlation of the data, gained, in order to predict field water status after defined precipitation or irrigation events. The novel development of a dynamic soil moisture sensor enables a data acquisition on the go at a resolution of 1 Hz. Therefore the evaluation of field characterising hydrological potential gets real. One major limiting factor of the system is the penetration depth of the dynamic TDR evidence. The prediction model has to deal with a shallow top soil layer. The combination of two datasets is promising, whereas the underlying soil fraction is documented in $\sum$ values of electrical conductivity, which is contrasting the solitary acquisition of volumetric water content in an upper soil layer.